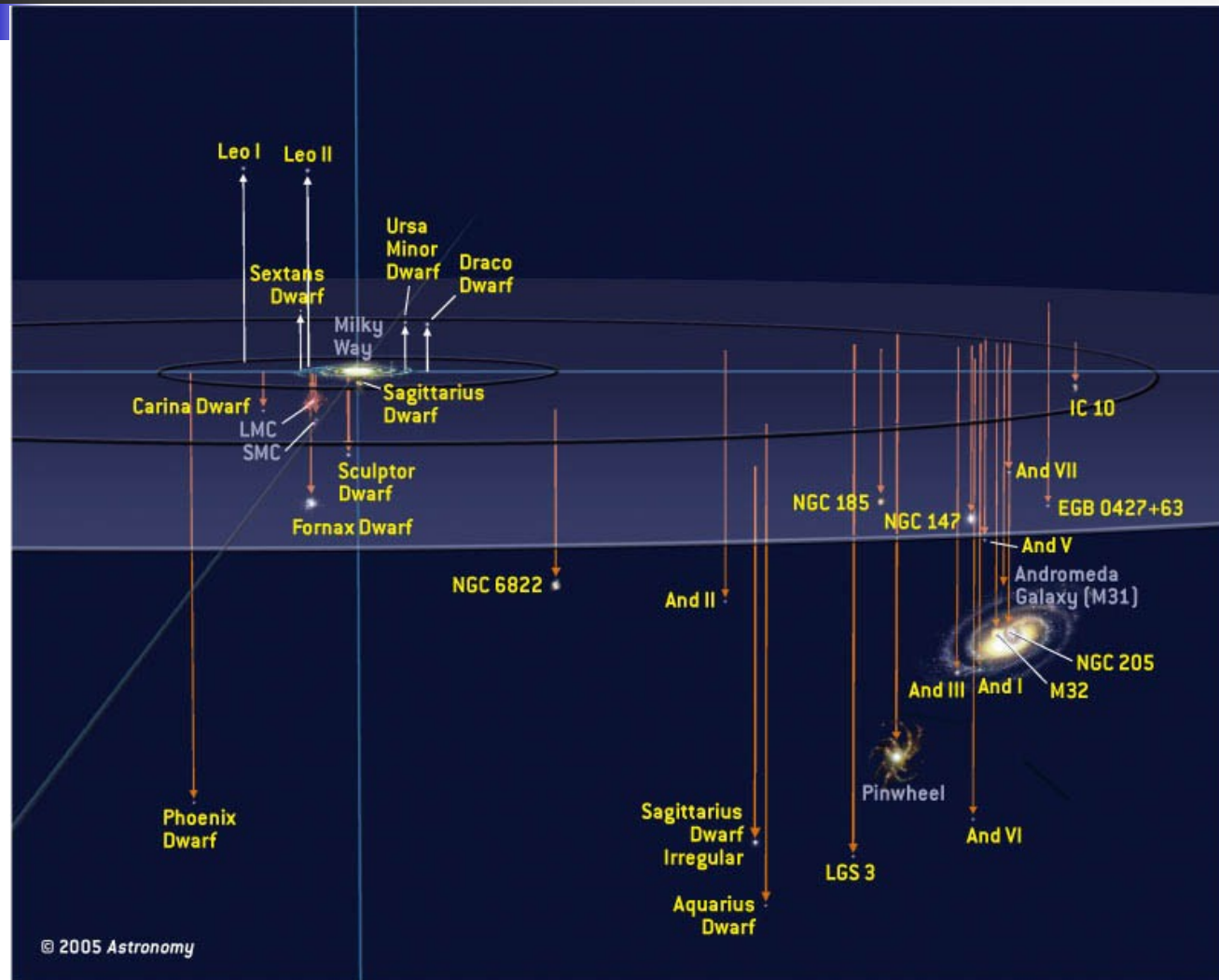




Local Group

Our Galactic Archipelago

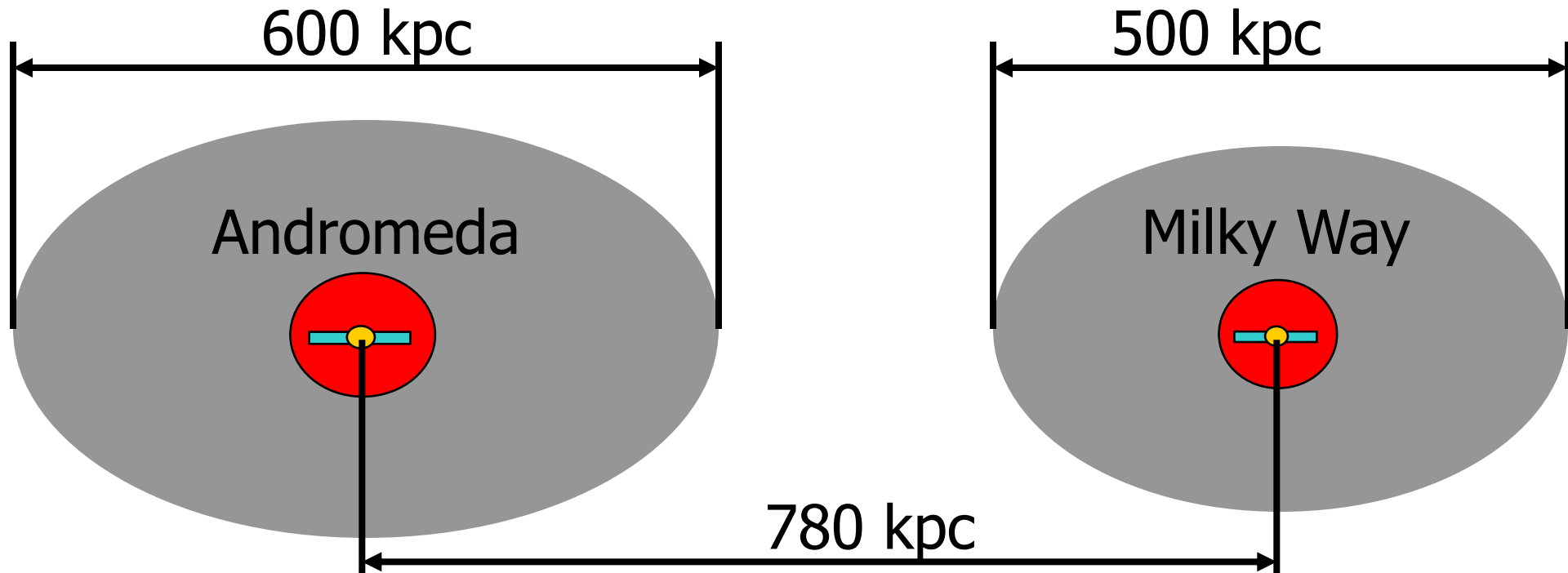
Our Neighbors





A Dark View

- Dark matter halos of the Milky Way and Andromeda, on scale.



Andromeda Galaxy (M31)

- Another typical spiral galaxy. It is visible with a naked eye in the constellation of Andromeda (hence its name).
- The most distant object visible with a naked eye.
- First photograph in 1887 by Isaac Roberts (amateur astronomer).
- Roberts thought it was a planetary system in formation.





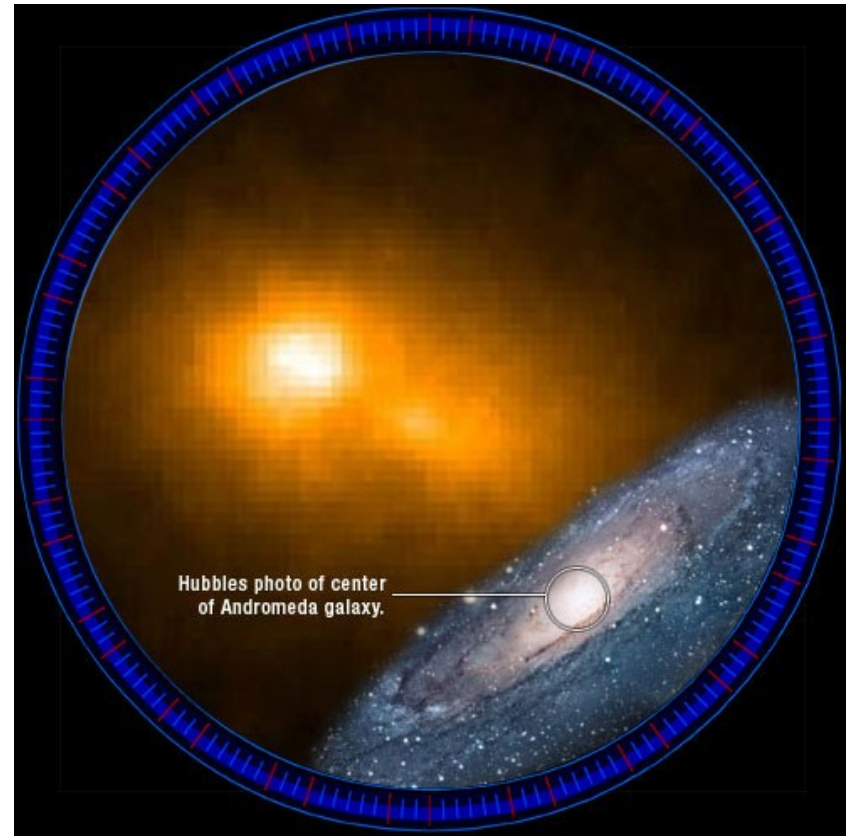
Andromeda vs The Milky Way

	<i>The Milky Way</i>	<i>Andromeda</i>
■ Total mass:	$1.0 \times 10^{12} M_{\odot}$	$1.5 \times 10^{12} M_{\odot}$
■ Disk mass:	$5 \times 10^{10} M_{\odot}$	$7 \times 10^{10} M_{\odot}$
■ Bulge mass:	$1 \times 10^{10} M_{\odot}$	$2 \times 10^{10} M_{\odot}$
■ Halo radius:	250 kpc	300 kpc
■ Fraction of gas:	20%	7%
■ Rotation speed:	220 km/s	270 km/s

■ Its bulge is bigger than ours, but it has less gas. Keep this in mind, it does mean something!
--

Andromeda's Mystery

- Andromeda galaxy has a bizarre double nucleus. What could cause it?
 - **A:** two black holes orbiting each other.
 - **B:** a dust lane crossing a single nucleus.
 - **C:** a globular cluster close to the center.
 - **D:** a lopsided, elongated disk of stars around the nucleus.





Retinue for the Queen

- Both of the two large galaxies in the Local Group have many smaller ones as ***satellites***. The Local Group is made of the Milky Way and Andromeda subgroups.
- Most famous of our satellites are ***Large*** and ***Small Magellanic Clouds*** (LMC and SMC).
- Magellan was the first European to describe them.
- They are located in the Southern hemisphere, and so are not visible from Europe. The LMC is just visible from the southernmost point in Arabia; Arabs knew about it.





Magellanic Clouds

	<i>LMC</i>	<i>SMC</i>
■ Distance:	$49 \pm 1 \text{ kpc}$	$61 \pm 3 \text{ kpc}$
■ Size:	8 kpc	3 kpc
■ Total mass:	$2.0 \times 10^{10} M_{\odot}$	$6.0 \times 10^9 M_{\odot}$
■ Disk mass:	$4 \times 10^9 M_{\odot}$	$1 \times 10^9 M_{\odot}$
■ Rotation speed:	70 km/s	50 km/s
■ Metallicity:	0.5	0.2

■ Magellanic clouds have no bulges, and their disks are rather disturbed. They belong to the category of <i>irregular</i> galaxies.
--

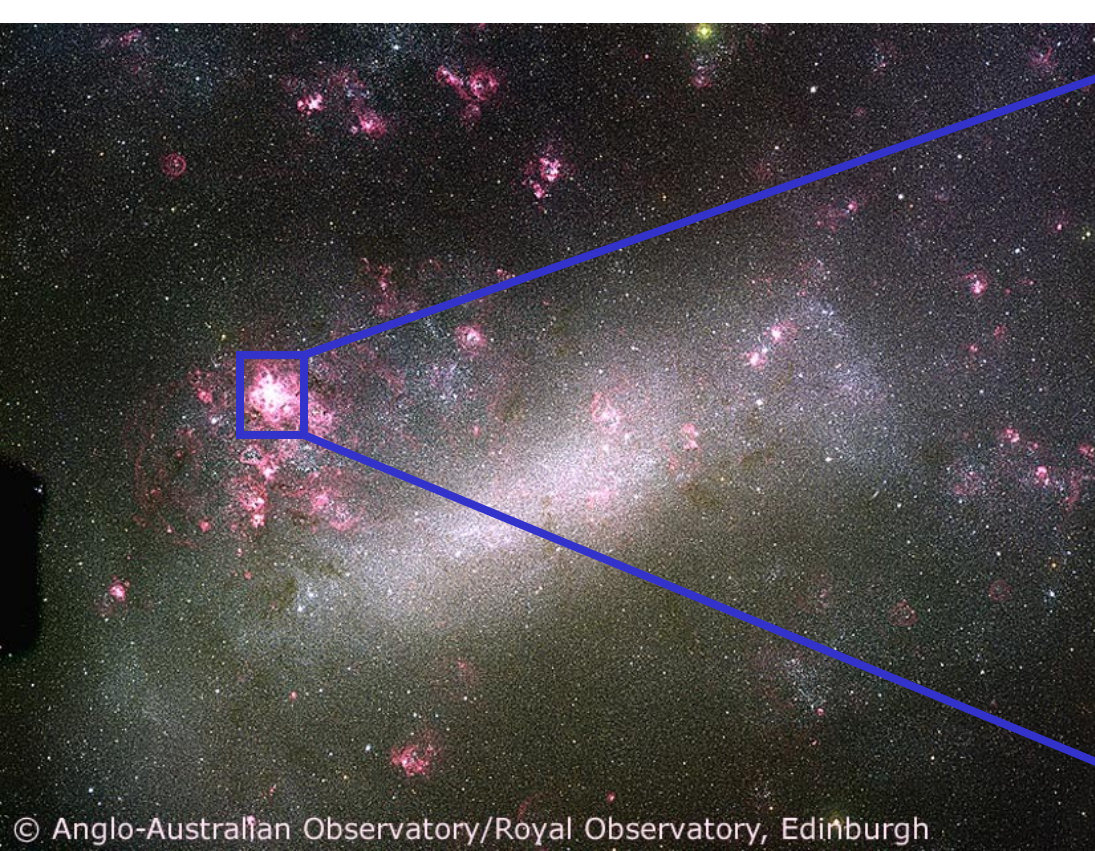


Why Are Magellanic Clouds Irregular?

- **A:** They are too small to be regular.
- **B:** The Milky Way disturbs them.
- **C:** Their centrifugal forces are irregular.
- **D:** Small galaxies do not deserve to have perfect shapes.

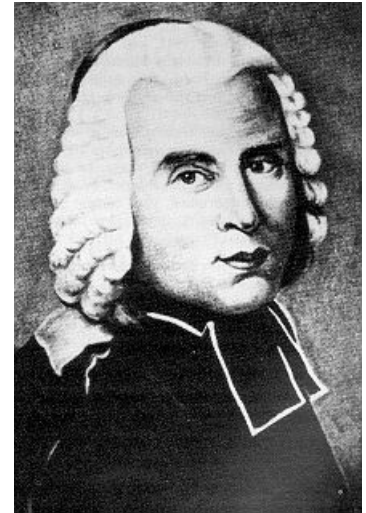
Tarantula Nebula

- Magellanic clouds are otherwise rather undistinguished, except for one thing.



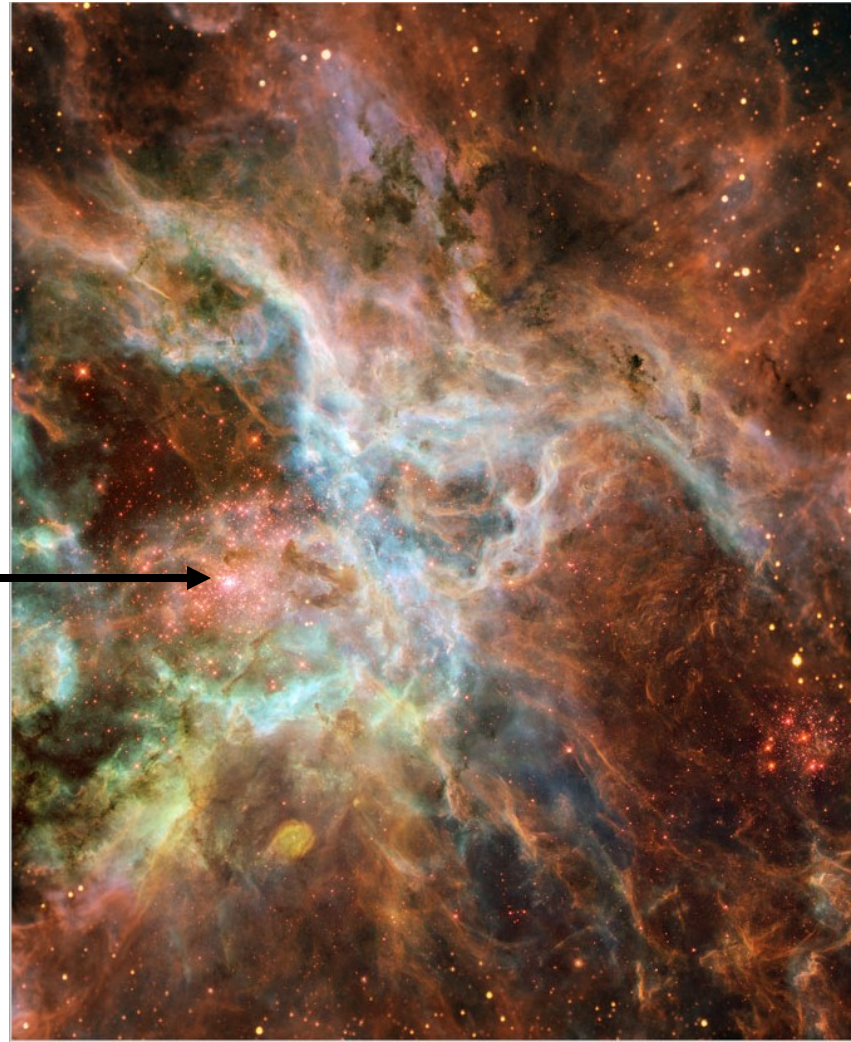
Nicolas de Lacaille (1713 – 1762)

- French astronomer, studied Southern skies.
- Introduced 14 new constellations.
- Cataloged 10,000 new stars (manually! – computers were not very fast back then).
- In 1751, identified Tarantula nebula as a nebula, rather than a star.
- Lalande (another French astronomer) said of him that, during Lacaille's short life, he had made more observations and calculations than all the astronomers of his time put together.



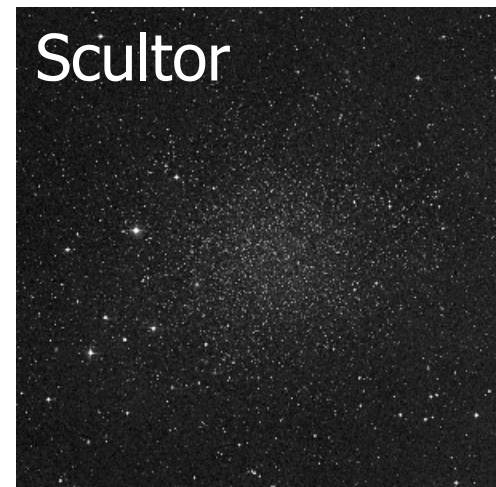
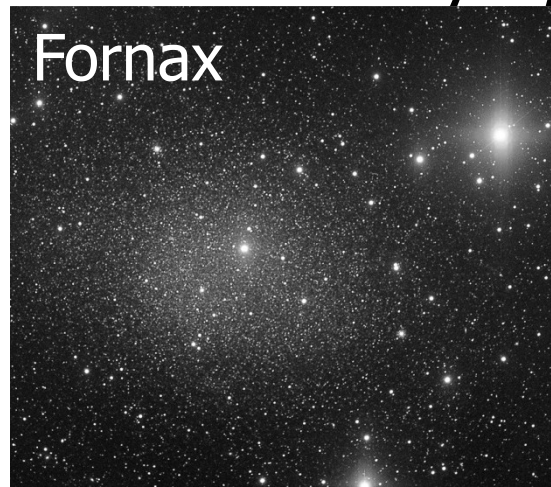
Tarantula Nebula

- The largest star forming region in the whole Local Group.
- At a distance of Orion, it would cast shadows at night.
- The main cluster of young stars contains 1,000 young massive stars; 12 of them are bigger than $40 M_{\odot}$.



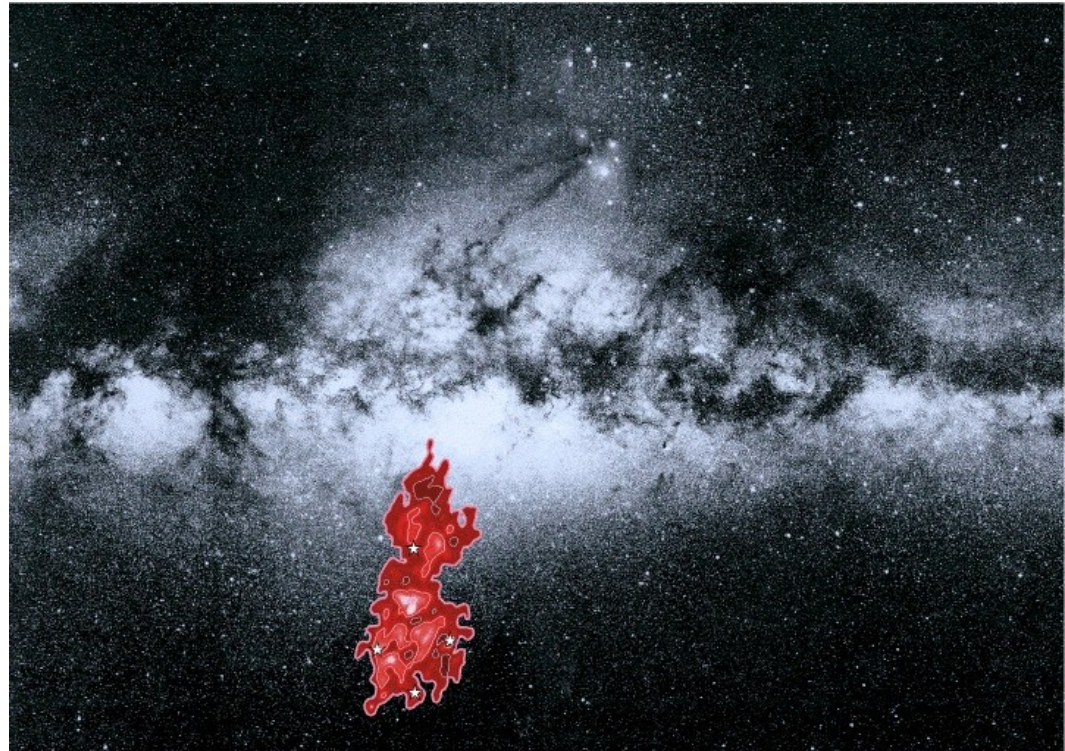
Dwarf Spheroidals

- In addition to LMC and SMC, the Milky Way has about two dozen smaller satellites, called ***dwarf spheroidal*** galaxies (or dwarf spheroidals).
- New dwarf spheroidals are being discovered every year, the smallest one (Willman I) has a diameter of 100 pc (less than the thickness of the MW disk) and consists of only 2,000 stars.



Sagittarius Dwarf Spheroidal

- The most famous of all dwarf spheroidals is the Sagittarius dwarf. This is because the Milky Way is dining on it ***right now!***
- Nearest galaxy to the Milky Way.
- Discovered in 1994, by Rodrigo Ibata, Mike Irwin, and Gerry Gilmore.
- It can ***not*** be identified on a photograph.





$t=0\text{Myr}$



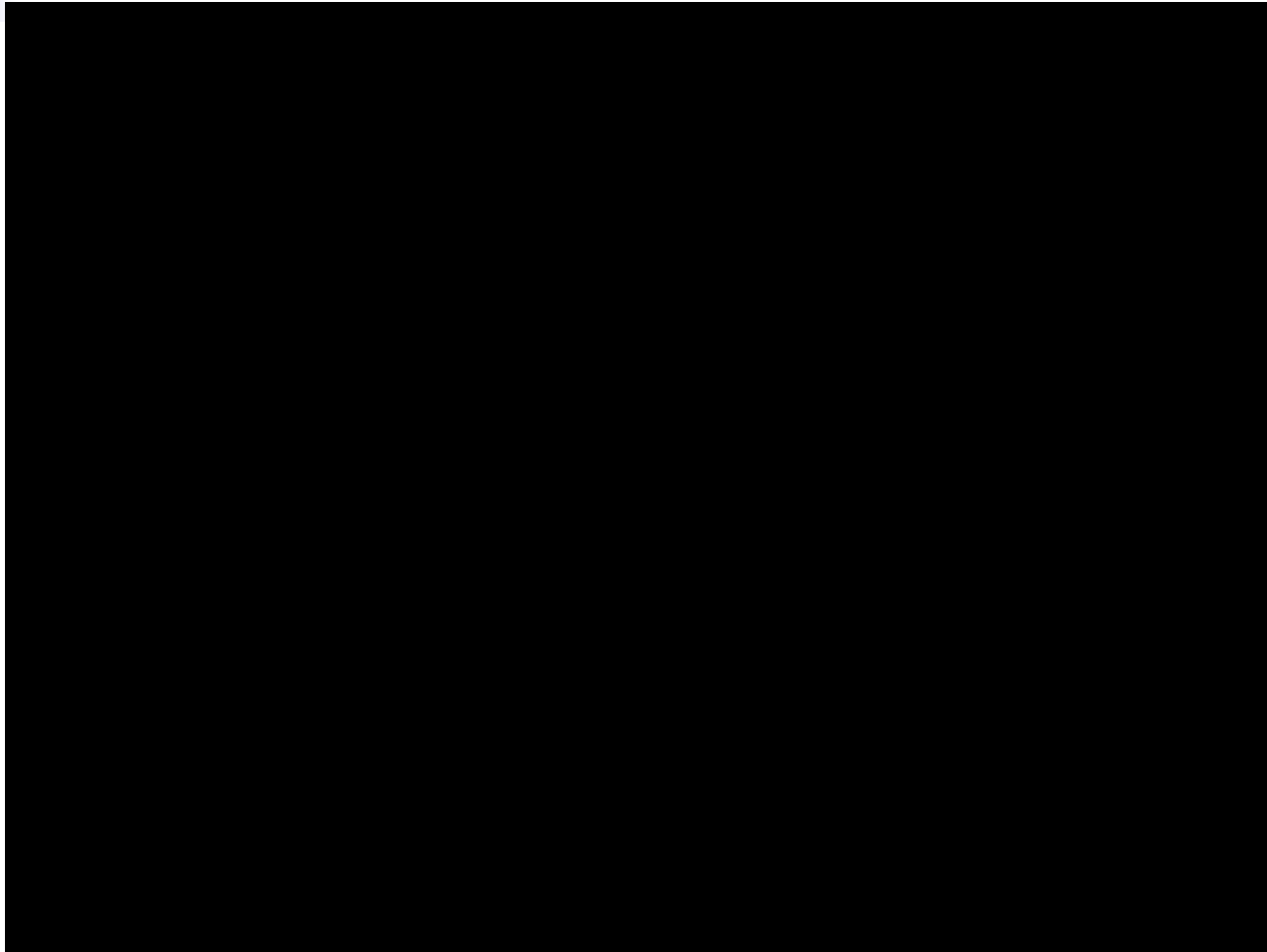
What We Are Going To Miss...

- Future is even more spectacular – the Andromeda galaxy is actually moving towards us at about 270 km/s – the two big spirals are going to collide in about 3 Gyr.
- What is the chance that a star from Andromeda will hit the Earth and destroy it?
 - **A:** 100%
 - **B:** 20%
 - **C:** 1.4%
 - **D:** 0.001%
 - **E:** 0



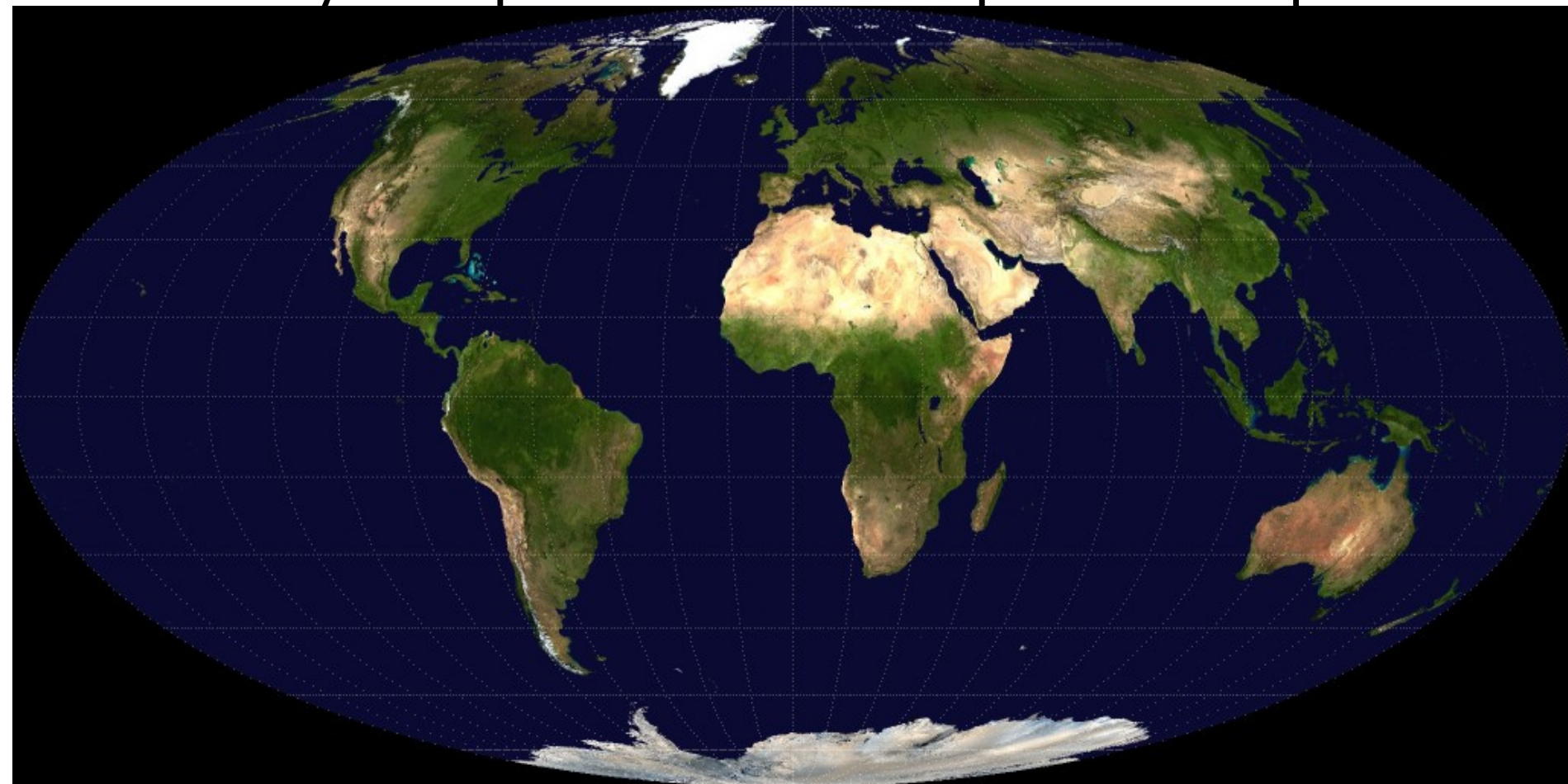


Spiral Metamorphosis



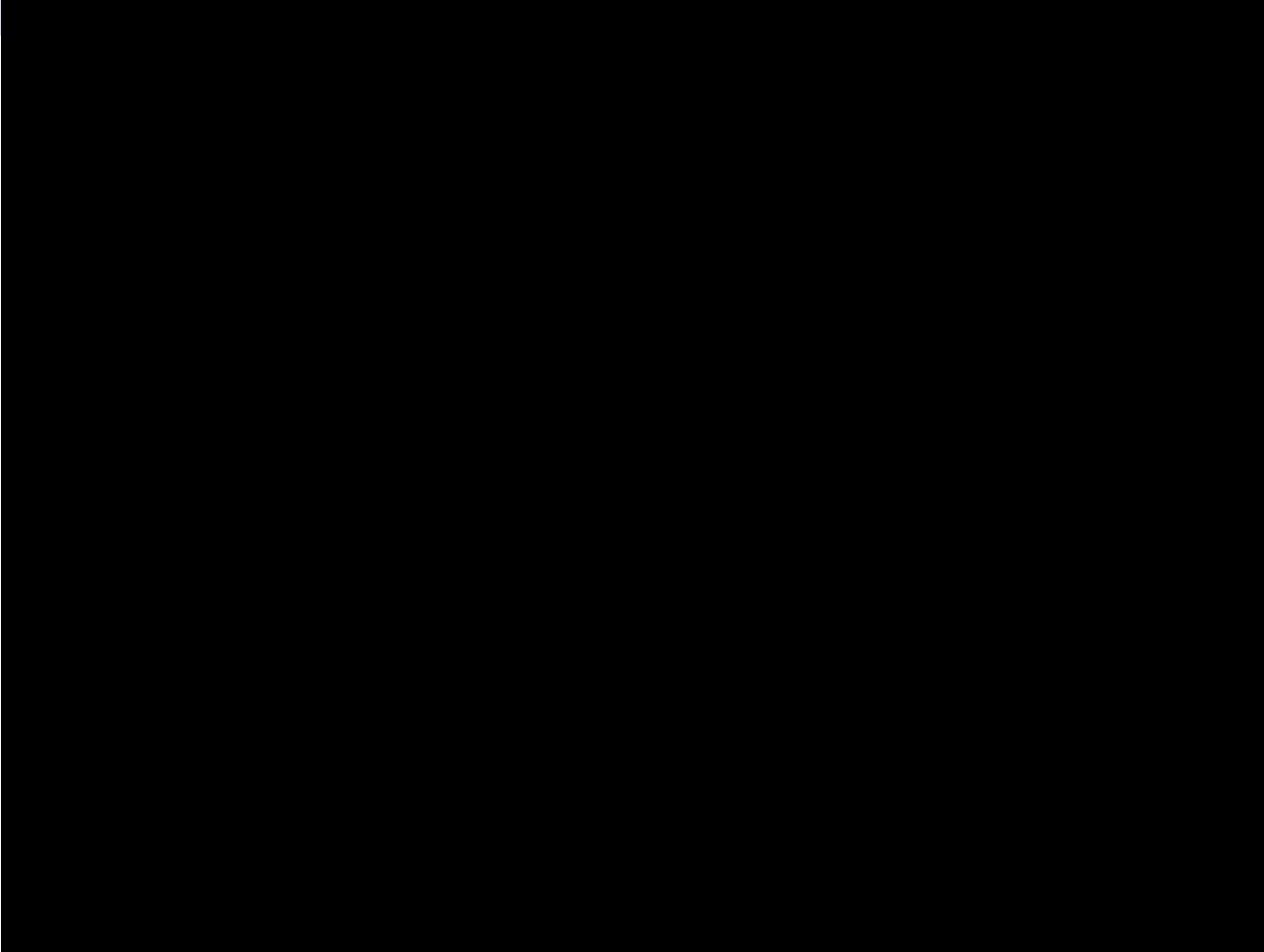
Mollweide Projection

- A way to represent a whole sphere on a plane.



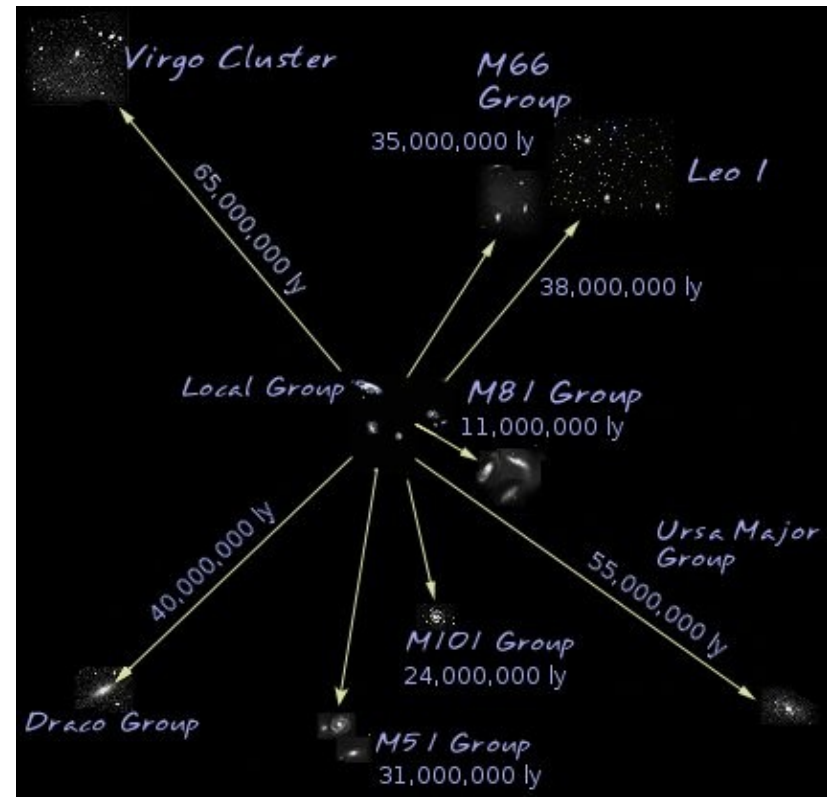


Future Sky



Beyond the backyard

- There are several small galaxy groups like the Local Group around us. But we are living in the suburbia of galactic life.
- Most galaxies live in groups like the Local Group or somewhat larger.
- But there are also towns and cities in Galaxiland...



Virgo Cluster

- A medium-sized cluster of galaxies (town).
- 1,000 galaxies
- Distance: 18 Mpc
- Mass: $7 \times 10^{14} M_{\odot}$
- Center: M87



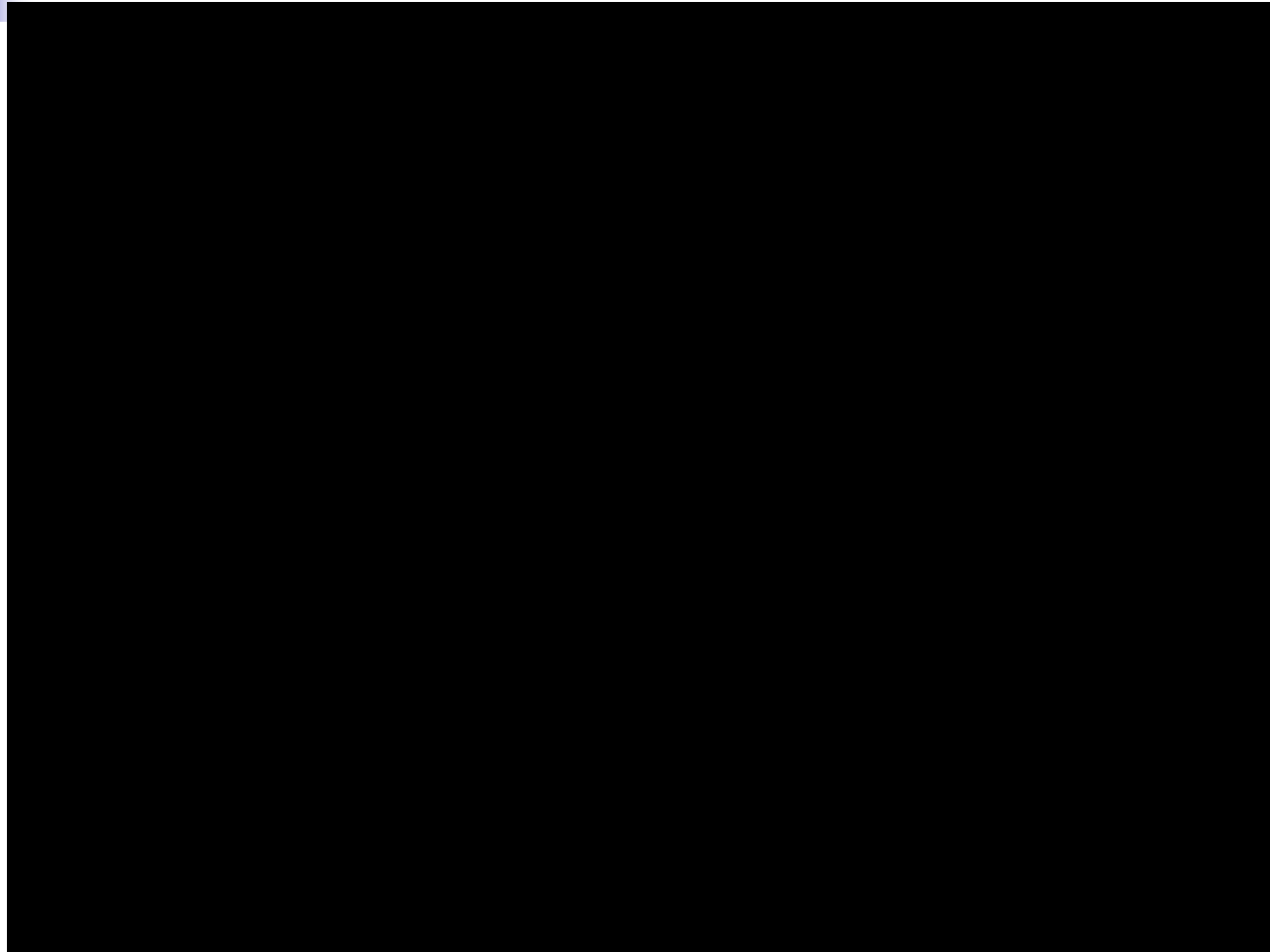
Coma Cluster

- A giant cluster of galaxies (city).
- >5,000 galaxies
- Distance: 99 Mpc
- Mass: $1.3 \times 10^{15} M_{\odot}$
- Center: NGC 4889

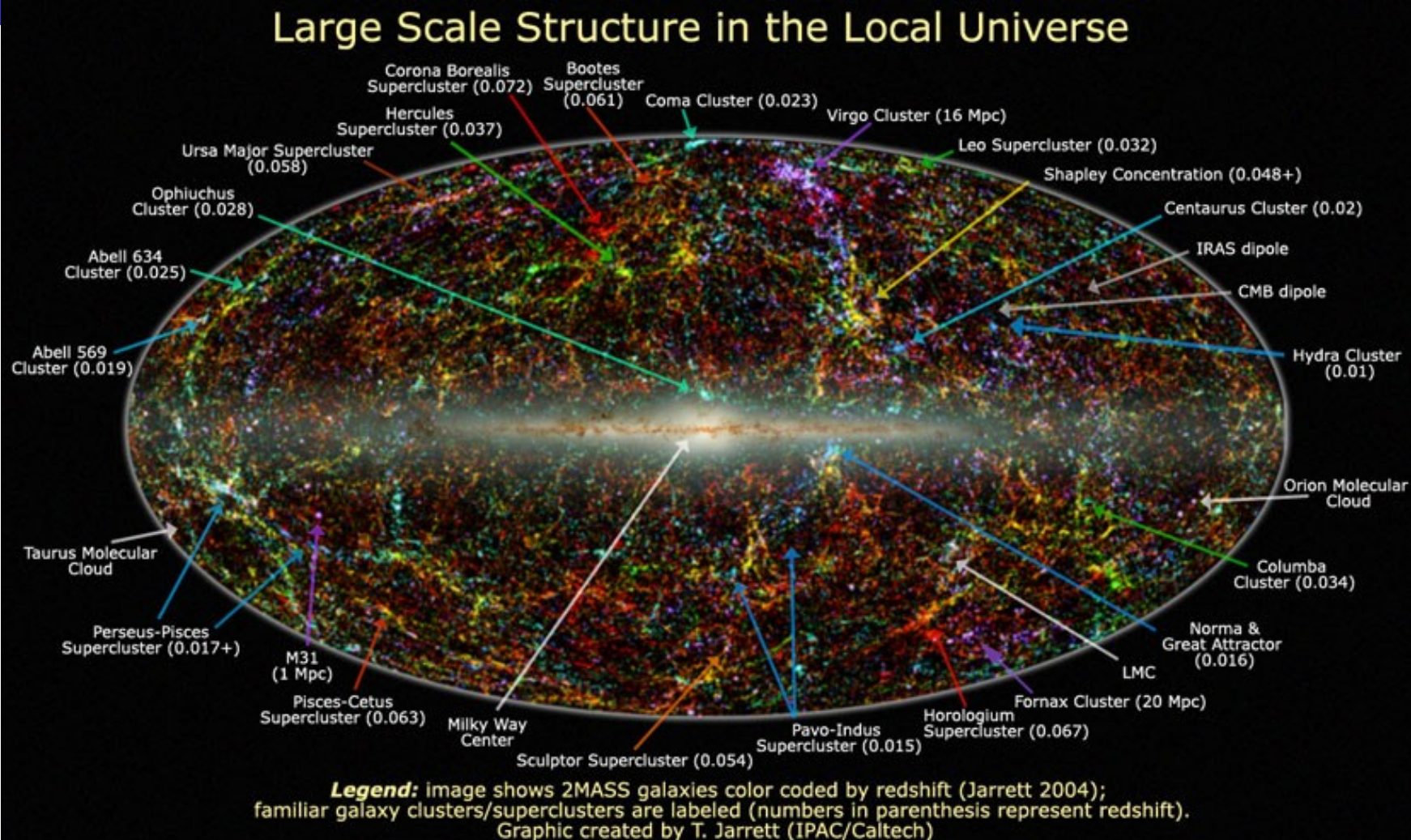




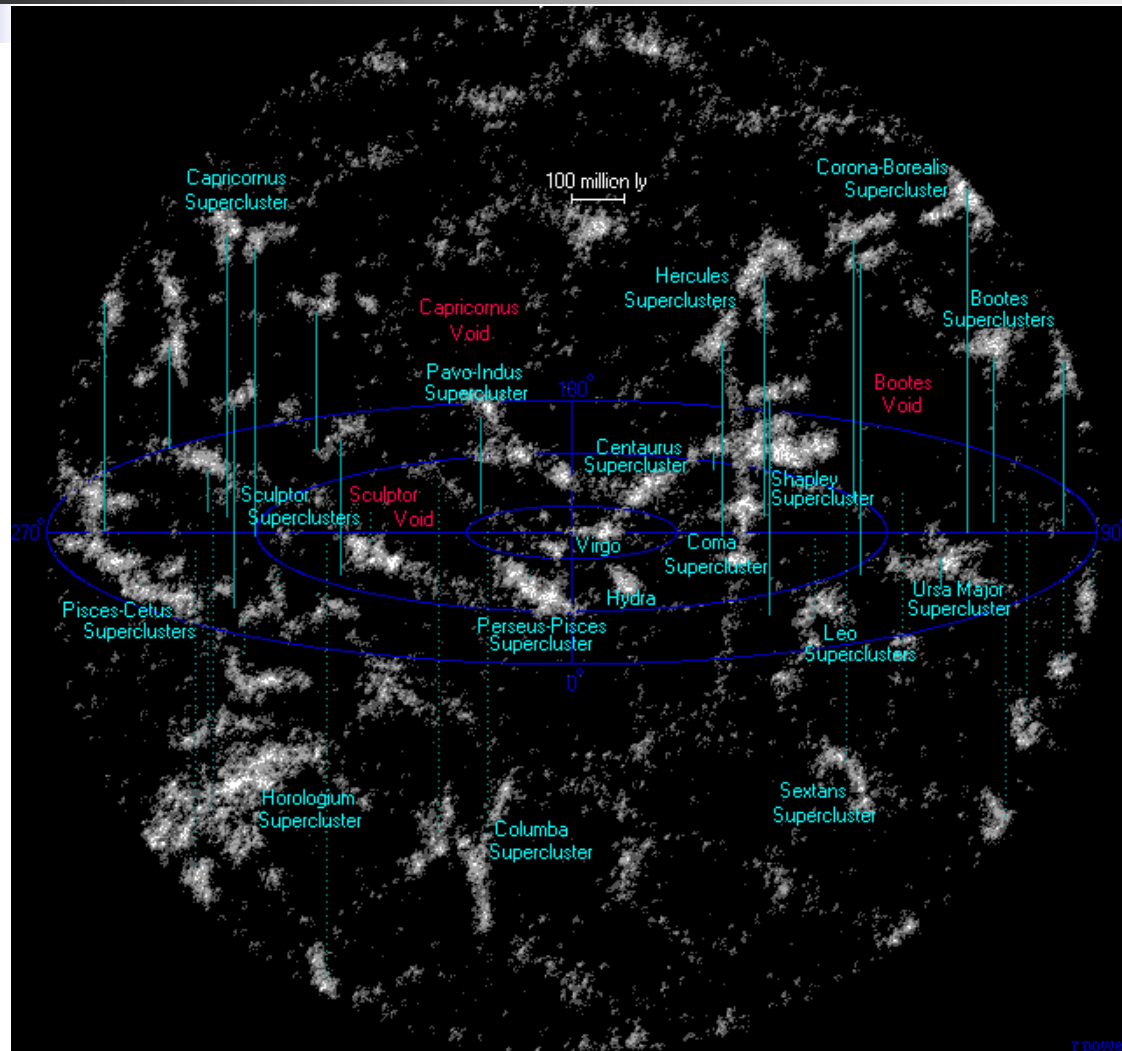
Social Life in the City



Local Universe: Sky



Local Universe: Space



**If it looks like large-scale structure, and
If it behaves like large-scale structure, it's...**

